

Product recalls: The effects of industry, recall strategy and hazard, on shareholder wealth

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Abstract

The purpose of this paper is to provide insights into the effects of product recalls on shareholder wealth of manufacturing firms in different supply chains. Previous research examining this phenomenon is largely uni-sectorial and/or does not consider the interplay of hazard, recall strategy and sector. By utilizing the event study method, this study examines investors' reactions to key product recall characteristics: industry, recall strategy and hazard level, on a cross-industry sample of 296 product recall announcements. The results show a significant negative reaction of share values to product recalls and significant differences between industry type and hazard levels. More regulated and stringent supply chains, such as the automotive and pharmaceutical, showed statistically significant losses in share price. The results show that industry sector and level of hazard associated with defective products are significant factors impacting the shareholder wealth of manufacturing firms. Contrary to some studies, the impact of recall strategy was not confirmed, although proactive recall strategies led, in some cases, to an increase in share price. Further research would benefit from more detailed investigation of recall strategies on the value of companies in specific sectors, particularly ones which are susceptible to frequent and costly product recalls.

Keywords: product recall, cross-industry sector, shareholder wealth, event study, product hazard, recall strategy, reverse logistics

1. INTRODUCTION

A product recall is the act of requesting the return of a batch or an entire production run of a commercial product, usually because of a defect, safety concern, or efficiency problem. It is an example of crisis caused by product-harm and is defined by Dawar and Pillutla (2000, p. 215) as a “discrete, well-publicised occurrence wherein products are found to be defective or dangerous”.

Product recalls transcend supply chains and can have significant negative effects for firms and their supply chain partners. The Japanese company Takata, in 2016, recalled 35 to 40 million airbags, due to the explosion risk they posed to drivers and passengers. The airbags have so far been linked to at least 10 deaths in the US. The total number of faulty airbags in the US alone exceeds 69 million, according to The National Highway Traffic Safety Association (NHTSA), a burden big enough to result in Takata’s bankruptcy (Money CNN, 2017). Further, in complex supply chains, recalls can be pervasive. In 2013, for example, Europe encountered what was to become known as the “horsemeat scandal”, when horsemeat was discovered in a wide range of ‘beef’ products. The effect was supply chain-wide, leading to food manufacturers, retailers and restaurant chains across Britain, Ireland, France, Spain, Germany, Denmark, Sweden and Norway recalling an ever increasing range of food products containing traces of horse DNA (BBC News, 2013).

Recalls can adversely affect firm’s performance (Chang et al., 2015), reduce brand equity, damage its reputation, cause panic among consumers, result in revenue and market share losses (Laufer and Coombs, 2006; Van Heerde et al., 2007; Chen et al., 2009) and cause an extensive amount of product returns (Genchev et al., 2011). While the long-term effects of supply chain disruptions, including product recalls on a firm’s brand, reputation or future revenues, are difficult to estimate (Hendricks and Singhal, 2005a, Zhao et al., 2013), estimating the short-term impact on shareholder wealth is possible using event study methodology (cf. Hendricks and Singhal, 2003; Eilert et al., 2017). The key premise behind this methodology is that an efficient market reacts instantaneously to an event (in our case a product recall announcement), that could change a stock price evaluation (Brown and Warner, 1985; MacKinlay, 1997).

To date, the relationship between product recall announcements and shareholder wealth, using event study methodology, has been examined, but studies are limited in their scope and inconclusive regarding the levels of impact. Product recalls have been studied: a) in isolation of factors that influence the magnitude and directionality of investors’ reactions (e.g. Jarrell and Peltzman, 1985; Govindaraj et al., 2004); and/or b) where influencing factors – such as industry sector, recall strategies or hazard – have been considered, but have been examined in specific supply chains or product categories (e.g. retail focus by Ni et al., 2014) or geographical samples (e.g. the Chinese market only by Zhao et al., 2013).

In order to extend our understanding of the short-term financial impact of product recalls, we employed the event study methodology on a global, cross-industry sample of 296 product recall announcements, spanning over a period of ten years. In doing so, we examine both; a) the relationship between product recall announcements and investors’ reactions and b) the effects of three influencing factors: supply chain sector, recall strategy and hazard.

This study makes two key contributions: first, it extends our understanding of product recall announcements on shareholder wealth in a global, cross-supply chain context, which has not been done to date; second, it provides a more granular insight into the effects that industry, recall strategy and hazard have on the magnitude and directionality of investors’ reactions.

In the next section we introduce the theoretical background and develop the research hypotheses. This is followed by the method employed in the research. We then present the results of the study, followed by the discussion. Finally, we close the paper with conclusions and managerial implications.

2. THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

By drawing on inter-disciplinary literature from supply chain management, marketing, economics and finance, we develop in this section a series of testable hypotheses, beginning with a financial impact of product recalls.

2.1. Financial Impact of Product Recalls

Studies examining the short-term impact of product recalls on manufacturers’ share price have been largely uni-sectorial. Manufacturers in automotive supply chains have been the focus of studies by Jarrell and Peltzman (1985); Hoffer et al. (1987); Bromiley and Marcus (1989); Govindaraj et al. (2004); Chen et al. (2009); Zhao et al. (2013), pharmaceutical industry by Jarrell and Peltzman (1985); Pruitt and Peterson (1986); Ahmed et al. (2002); Zhao et al. (2013), with a few examining other

industries, such as, electronics, food, consumer goods and toys respectively (e.g. Pruitt and Peterson, 1986; Thomsen and McKenzie, 2001; Chen et al., 2009).

In general terms, firms that experience supply chain glitches report on average 6.92% lower sales growth, 10.66% higher growth in cost, and 13.88% higher growth in inventories (Hendricks and Singhal, 2005b). The extant studies show that product recall announcements result in the decline of the affected firm's stock price. For example, Jarrell and Peltzman (1985) showed that in both the pharmaceutical and automotive industries, shareholders experienced financial losses that exceeded the direct costs of recalling faulty drugs and automobiles. Zhao et al. (2013), showed that the Chinese stock market also reacts significantly negatively to product recall announcements. A similar conclusion about the negative impact of product returns on shareholder wealth was drawn by Ni et al. (2014), in their study of retailers.

However, the extant research is equivocal that the stock market regards a product recall as negative; moreover, there is a lack of consensus about the magnitude of the markets' reaction. These estimates range from -0.4% (Thomsen and Mackenzie, 2001) to -10.57% (Govindaraj et al., 2004). Given the above, we hypothesize:

H1: A product recall announcement will generate a negative stock market reaction.

2.2. Effect of industry

Beyond the impact of product recalls on shareholders' wealth, we are interested in more specific factors that can influence the stock market's reaction. To date, research has generally examined the impact of product recalls on shareholder wealth using single industry samples, within which the automotive supply chains dominate (e.g. Hoffer et al., 1987; Bromiley and Marcus, 1989; Govindaraj et al., 2004). The few studies that utilized multi-industry samples, did not test the effects of industry (e.g. Jarrell and Peltzman, 1985; Pruitt and Peterson, 1986), or tested them in a particular geography such as China (Zhao et al., 2013). We anticipate that investors' reactions to product recall announcements will vary based on:

- Product lifecycles, cash-to-cash cycles and Return on Investment (ROI) periods differ between sectors. For example, in Pharmaceutical supply chains, a substantial upfront Research and Development (R&D) investment spanning anywhere between ten to fifteen years is needed before a drug is launched on a market. The R&D processes are stringent and must be agreed by the regulatory bodies before the drug can be launched (Ahmed et al., 2002; Di Masi et al., 2016). If successful, the drug will be marketed over a long period of time to recover the investment, before patent expiration and generics take significant market share. If an issue is found in a drug, it may be recalled and there could be a lengthy period before the drug re-enters the market. A drug may be 'withdrawn' rather than being simply recalled, if an associated health hazard is linked with it. As a consequence, a company will not only have difficulties in recovering the upfront investment, but it may also have to absorb costs related to law suits in case of significant health hazard for consumers. In the food sector, while health hazards to consumers may be similar (e.g. food poisoning resulting in severe illness), a food product can be recalled and replaced with a new product once the problem is discovered, without significant long-term additional costs. In the automotive supply chains, although a product recall may be associated with hazard, it can normally be rectified quickly through dealerships replacing defective parts. Even if an Original Equipment Manufacturer (OEM) has to redesign a part, this would take significantly less time than changing, for example, a compound in a medicine, nor would it result in a withdrawal of a particular car from the market.
- The frequency and value per claim of product recalls vary between industries. According to Allianz Insurance report, which examined latest trends in product recalls (Allianz Global Corporate and Speciality, 2017), automotive industry leads in terms of recall frequency - and it is responsible for 42% of all claims - followed by food/beverage (18%) and domestic appliances (10%). Automotive industry also leads in average product recall claim value, with EUR 2.12 million, followed by food/beverage at EUR 1.31 million and IT/Electronics with EUR 1.1 million. Comparatively, in pharmaceutical sector, the announcements are less frequent, due to the stringent testing and regulations in place (Narayana et al., 2014). In consequence, investors will factor both frequency and value of product recalls into their valuations and react differently to announcements in different industries.
- Industries also vary in terms of the ubiquitousness of their products. For example, food is a necessity rather than a luxury. Consequently, a significantly larger number of people can be affected by defective food, than, for example, by a defective toy. Also, as Zhao et al. (2013)

argued, the effect of bad food on the health of consumers is almost instantaneous, which is rarely the case with a defective car. Moreover, brand loyalty and availability of substitutes plays an important role in a market's reaction to product defects (Rhee and Haunschild, 2008). We posit that brand loyalty is much lower in the food industry compared to the automotive, and the choice of substitutes is higher. This postulation was evident in the 2013 European horsemeat contaminated beef burgers scandal. Tesco, the UK's largest supermarket, recorded a reduction in their overall sales ranging from -5.5% in the UK to -13% in Turkey (Leach, 2013).

This leads us to the following hypothesis:

H2: The reduction in stock price related to product recalls will have industry specific impacts.

2.3. Effect of Recall Strategy

In line with Zhao et al. (2013), we adopt Signalling theory to examine the impact of recall strategy and hazard in a product recall. Signalling theory is concerned with reducing information asymmetry between two parties and the description of behaviours when two parties (e.g. individuals or organisations) have access to different information (Spence, 2002). The theory hypothesises that a receiver (e.g. an investor and/or a consumer), interprets a signal from a sender (e.g. a firm that discovered a product defect) about the quality of a product and the firm's intent. The availability and clarity of information affects the decision making process. Individuals make decisions based on publically available information, as well as private information, which is available only to a subset of the public (Connelly et al., 2011).

In the context of product recalls, Chen et al. (2009), show that during a product recall crisis, information asymmetry (i.e. difference in the access to the same information) between firms, consumers and stock market investors, increases. Normally, through their traceability systems (Dai et al., 2015), firms possess significantly more information about a product recall than the stock market or consumers. Conversely, the stock market relies on multiple external sources of information, such as corporate or governmental announcements and the business press, to analyse a firm's actions and strategies, and to interpret those signals in terms of future earnings and firm value (Ross, 1977).

Firms' responses to product recalls differ. The extant literature (Dawar and Pillutla, 2000; Laufer and Coombs, 2006) classifies firms' responses to product recalls into four groups: denial, forced compliance (involuntary recall), voluntary recall, and 'super-effort'. Broadly, denial and involuntary recall fall under the category of passive responses, while voluntary recall and super-effort are proactive responses.

In a proactive response, a firm that discovers a product defect, either through internal inspections or external sources, releases a voluntary product recall. Kumar and Schmitz (2011) state that in 2009, the US Consumer Product Safety Commission recorded 465 voluntary product recalls involving 229.6 million product units. Voluntary recalls are released prior to any safety incidents or concerns being reported by consumers. In 2016, for example, Apple announced a voluntary recall of millions of its two prong AC wall plugs, after it became aware of their potential to break, causing an electric shock (BBC News, 2016).

A passive response, conversely, involves delaying the recall process or shifting the blame to other supply chain members, such as distributors, wholesalers and/or suppliers. Firms are particularly motivated to adopt a passive response when they discover a serious and pervasive product defect where they cannot profitably repair or replace all defective products. In these situations, companies may attempt to deceive consumers about unobserved quality attributes, hoping that the issues remain undetectable (Zhao et al., 2013). Consequently, firms that adopt a passive recall strategy tend to issue recall announcements much later, compared to proactive companies, often after serious complaints, injuries or even death to consumers (Chen et al., 2009).

The current evidence as to which product recall strategy is penalized with a higher negative abnormal stock return is mixed. Zhao et al. (2013) found stock markets in China reacted significantly more negatively to passive recalls. Their findings suggest that in China, investors perceive companies who adopt a proactive approach to product recalls as socially more responsible. This is in line with Margolis et al. (2007), who posit that a proactive approach enhances consumers' confidence in the firms' products and helps firms to recover sooner. Siegel and Vitaliano (2007) argue that a proactive approach is seen by consumers and investors as a signal of corporate responsibility, even when that event leads to reduced cash flows that may devalue a firm. In contrast, Chen et al. (2009) found that proactive recall strategies have a more negative effect on a firm's financial value than passive strategies. While the extant literature is mixed, most research suggests taking a proactive approach will be less punitive. Thus, we hypothesize:

H3: A passive product recall strategy will result in more negative abnormal returns than a proactive product recall strategy.

2.4. Effect of hazard

The hazard that recalled products pose to consumers varies between different recalls (e.g. Ahmed et al., 2002; Ni et al., 2014). Federal departments and previous research classify product hazard in various ways. The US Food and Drug Administration (FDA) applies a three-level classification to recalls based on product hazard (Food and Drug Administration, 2014). Class I refers to dangerous or defective products that could cause serious health problems or death; Class II refers to recalls where products might cause a temporary health problem, or pose only a slight threat of a serious nature; and Class III refers to recalls where products are unlikely to cause any adverse health reaction, but violate FDA labelling or manufacturing laws. Jarrell and Peltzman (1985) applied this classification to distinguish between severities of drug-related recalls.

For the assessment of hazard in automotive sector, Crafton et al. (1981) and Reilly and Hoffer (1983) developed recall classifications for the severity level of vehicle recalls, when investigating the impact of automotive recalls on consumer demand. Their classification labelled minor problems, such as mislabelled or missing placards and tyre-related difficulties, as a Type I recall; Type II recalls considered intermediate problems such as defective windshield wipers or problems with carburettor brackets; while Type III were recalls due to severe safety hazards, such as loss of steering and braking functions or early failure of an axle shaft.

Empirically, the effect of hazard on manufacturers, using cross-sectorial studies is yet to be tested. Given the variation in hazard levels, investors may react differently to recalls where faulty products pose a risk of severe impact to the health or even the death of consumers, as opposed to those where there are unlikely to be any adverse effects. We offer three arguments for this: First, firms would normally send a signal to the investors and public about the level of hazard posed by the product to be recalled. We anticipate that, irrespective of industry, investors would associate increased levels of hazard, leading to serious personal injury or death, as a signal of more serious, costly, and difficult to resolve problems. Such problems may result in the loss of market share, decreased profitability, damaged reputation and lengthy lawsuits (Zhao et al., 2013).

Second, due to loss aversion, investors' interpretation of a product recall signal that is linked to the greater hazard, results in greater stock depreciation. This reaction is rooted in the notion of loss aversion, which suggests that change for the worse is perceived in people's minds larger than an equivalent change for better (Novemsky and Kahneman 2005).

Third, as posited by Ni et al. (2014), product recall announcements linked to serious hazard are likely to receive substantially more media coverage. The FDA's and the Consumer Product Safety Commission (CPSC) websites are regularly updated with a plethora of product recalls with low levels of hazard, which never find their way into mainstream media. However, the newsworthy nature of recalls linked to serious injuries or death, is more likely to be reported by the media (Barber and Odean, 2008). Therefore, as argued by Ni et al. (2014, p. 314): "product recall announcements for a more severe product safety issue will receive greater media attention, leading to greater disutility by stakeholders." Thus, we hypothesize that:

H4: A higher level of hazard will lead to a greater reduction in stock price.

3. METHODOLOGY

In line with other research that examined the impact of product recalls on shareholder wealth (cf. Jarrell and Peltzman, 1985; Zhao et al., 2013; Ni et al., 2014), we used the event study methodology. In the following section we describe the data collection and analysis procedures.

3.1. Data

The process of identifying product recall announcements started with a free text search using the Factiva database focused on the Wall Street Journal (WSJ) - All Sources. This included its US, European and Asian printed editions, plus the online edition. Use of the WSJ as a source for recall announcements is in line with other studies that used the event study methodology (e.g. Hendricks and Singhal, 2003).

The search covered a ten year period from 2005 until 2014. The key search word used was "recall*", which yielded articles containing words such as "recall", "recalls", "recalled" or "recalling". Each article/announcement was screened to identify the nature of the recall and whether it was germane to product recalls. In this process we eliminated articles/announcements with the following characteristics:

- Articles/announcements which reported the same information made in an earlier announcement, unless new information was disclosed. Thus, only the first announcement of a product recall was taken into consideration;
- Articles/announcements related to privately owned companies, as there would be no publicly traded shares; and
- Articles/announcements and earnings pre-announcements where product recalls were mentioned. Product recalls can influence earnings expectations (Bowen et al., 1992), as they contain factors that can bias the perceptions of a firm’s performance.

The final sample consisted of 296, non-contaminated (i.e. no other recalls within the event window), product recall announcements, comprised of 150 recalls (50.7%) from automotive supply chain manufacturers; followed by 72 recalls from manufacturers in pharmaceutical supply chains (24.3%), 21 in food (7.1%), 20 in electronics (6.8%), 9 from toy (3.0%) and 24 (8.1%) from other supply chains. Following the sample selection, we developed a cross-industrial classification of hazard levels. This was necessary for testing H4, given that the selected announcements spanned multiple industries. We started the process by reviewing the classifications of three main US government regulation agencies:

- The Consumer Product Safety Commission (CPSC) responsible for consumer products;
- The Food and Drug Administration (FDA) which regulates consumer products encompassing food, pharmaceuticals, medical devices and cosmetics; and
- The National Highway Traffic Safety Association (NHTSA), responsible for regulating the automotive industry.

We further reviewed regulatory bodies in other countries and industries and consolidated these in the following way (see Table 1):

- Class I involves recalls that could lead to death or severe injury;
- Class II comprises recalls that may cause a temporary health problem or a minor to moderate injury; and
- Class III is composed of defects that are not likely to have health or safety threats, but breach the legislation.

Table 1: Hazard level classification across industry

	Automotive	Pharmaceutical & Food	Toy & Electronics
Class I	Death or severe injury caused by road accidents or fire, or risks that can be devastating	Dangerous or defective products that predictably could cause serious health problems or death	Death or severe injury caused by choking or exploding, etc., or predictably could cause serious health problems
Class II	Minor or moderate injury caused by road accidents or fire	Products that might cause a temporary health problem, or pose only a slight threat of a serious nature	Minor or moderate injury or adverse health reaction
Class III	Defects that are not causing any road accidents or fires	Products that are unlikely to cause any adverse health reaction, but that violate FDA labelling or manufacturing laws	Defects that are unlikely to cause any adverse health reaction or safety-related risks

3.2. Event Study Method

In order to determine the impact of product recalls on shareholder wealth, we utilized the event study methodology (McWilliams and Siegel, 1997; Hendricks and Singhal, 2003; Eilert et al., 2017). This methodology utilizes daily stock returns to estimate the abnormal share price changes due to product recall announcements. It takes into consideration both industry and systematic risks, while also estimating investors’ reactions to specific events (Brown and Warner, 1980, 1985; MacKinlay, 1997). It assumes that an efficient market immediately reacts when an event that could change a stock price value is announced. The method has been previously applied in the fields of operations and supply chain management, marketing, information technology and accounting, to examine phenomena such as the increase in capital expenditure (McConnell and Muscarella, 1985), new product introduction

(Chaney et al., 1991), strategic alliance or acquisitions (Chan et al., 1997), supply chain glitches (Hendricks and Singhal, 2003), and innovative IT investments (Dos Santos et al., 1993).

We adopted this method in line with Hendricks and Singhal (2003), Zhao et al. (2013) and Ni et al. (2014), who used a modified version of Fama et al. (1969), to evaluate the daily stock returns. Appendix A provides an overview of the method used. The following section contains the results.

4. RESULTS

4.1. The Financial Impact of Product Recalls

The results from the event study are summarized in Tables 2 and 3. Table 2 shows the daily abnormal return during the event window of 296 product recall announcements. It demonstrates that on announcement day (Day 0), the mean abnormal return is -1.34%, while the cumulative mean abnormal return over the 3-day event period is -1.87%. As shown in Table 2, there are statistically significant results for mean, median and percentage of negative abnormal return on Day -1 and Day 0, while the abnormal return on Day 1 is not significant at the 5% level. The negative abnormal return on days -1 and 0 is in line with the results of other product recall studies using the methodology (e.g. Ahmed et al., 2002; Chu et al., 2005; Zhao et al., 2013). However, the magnitude of the negative abnormal return in our study (i.e. -1.87%), is significantly higher than in previous studies that examined more than one industry (e.g. Jarrell and Peltzman, 1985; Pruitt and Peterson, 1986; Chu et al., 2005).

Table 2: Abnormal returns for 296 product recalls announcements - event period from day -1 to day 1

	Day -1	Day 0	Day 1	Event Period (Day -1 to Day 1)
Mean abnormal return	-0.30%	-1.34%	-0.23%	-1.87%
t-statistic	-3.04	-2.96	-1.44	-4.21
Median abnormal return	-0.11%	-0.25%	-0.01	-0.222%
Wilcoxon signed-rank test Z-statistic	-1.726	-2.049	-.694	-2.554
Abnormal returns negative (%)	55.74%	58.78%	52.03%	61.82%

Table 2 indicates that the results support H1 that investors react negatively to product recall announcements. This results in a significant ($t=4.21$) cumulative abnormal return during the event window, and a negative impact on shareholder wealth. Table 3 shows the Dollar change in the stock price for the product recall announcements in this study.

Table 3: Description of Dollar change in stock price for the 296 product recall announcements

Mean	-US\$362.6m
Median	-US\$55.7m
S.D.	US\$2,564.4m
Maximum	US\$5,840.4m
Minimum	-US\$37,250.4m

From Table 3 it can be determined that the average Dollar loss over the event period (day -1 > day 1) is US\$ 362.6 million.

4.2. The Effects of Industry, Recall Strategy and Hazard on Abnormal Stock Returns

4.2.1. Descriptive Statistics

Table 4 shows the descriptive, cross-tabulated results for both industry and hazard level. The figure in parenthesis is the proportion of hazard level results within the industry.

Table 4: Descriptive results of industry and hazard classification

Industry	Class I	Class II	Class III	Unclassified	Total
Automotive	4 (2.67%)	12 (8.00%)	125 (83.33%)	9 (6.00%)	150

Pharmaceutical	24 (33.33%)	25 (34.73%)	15 (20.83%)	8 (11.11%)	72
Food	4 (19.05%)	7 (33.33%)	6 (28.57%)	4 (19.05%)	21
Electronics	-	5 (25.00%)	13 (65.00%)	2 (10.00%)	20
Toys	6 (66.67%)	-	-	3 (33.33%)	9
Miscellaneous	8 (33.33%)	6 (25.00%)	8 (33.33%)	2 (8.34%)	24

Table 4 shows that recalls from manufacturers in automotive supply chains are the largest proportion of recalls within the sample. Pharmaceutical recalls are the next largest number (n=72) and they comprise one third of recalls for the most severe form (Class I).

4.2.2. Effects of Industry

The statistical results for Cumulative Average Abnormal Return (CAAR) by industry are presented in Table 5.

Table 5: Statistical results of cumulative average abnormal return by industry

Industry	N	Mean	Std. Deviation	Std. Error	p-value (t-value)
Automotive	150	-0.0078	0.0210	0.0017	0.000 (-4.536)
Pharmaceutical	72	-0.0460	0.1408	0.0166	0.007 (-2.774)
Food	21	-0.0016	0.0185	0.0040	0.692 (-0.402)
Electronics	20	-0.0024	0.0182	0.0041	0.565 (-0.586)
Toy	9	-0.0258	0.0713	0.0238	0.309 (-1.085)
Miscellaneous	24	-0.0395	0.0788	0.0191	0.055 (-2.066)

From Table 5 it can be seen from the mean results that the manufacturers in pharmaceutical supply chains have the highest CAAR during the event period (day -1 > day 1), followed by miscellaneous (mean= -0.0395) and the toy supply chains (mean= -0.0258). However, only the automotive (p= 0.000, t= -4.536) and pharmaceutical industries (p= 0.007, t= -2.774) underwent significant changes to share prices. In order to check for statistically significant differences between groups (cf. Hendricks and Singhal, 2003), we conducted an analysis of variance (ANOVA). The ANOVA indicated that there was a statistically significant difference between groups (p= 0.014), indicating that the CAAR was different between sectors. Thus, H2 (The reduction in stock price related to product recalls will have industry-specific impacts) is supported.

4.2.3. Effects of Recall Strategy

The impact of product recall strategy (i.e. proactive or passive), on CAAR is captured in Table 6. From the table, it can be determined that passive recalls have a CAAR that is statistically significantly different compared to the market. This indicates that manufacturers that adopted a passive strategy suffered a greater loss in share price compared to those that adopted a proactive strategy. The results of the ANOVA (p= 0.372) indicate there is no statistically significant difference between recall strategy types, potentially indicating there is some overlap in the distributions for each strategy.

Table 6: Statistical results of cumulative average abnormal return (CAAR) by recall strategy

	N	Mean	Std. Deviation	Std. Error	p-value (t-value)
Proactive	98	-0.011	0.068	0.007	0.098 (-1.670)
Passive	136	-0.025	0.091	0.008	0.002 (-3.222)
N/A	62	-0.016	0.047	0.006	0.011 (-2.636)
Total	296	-0.019	0.076	0.004	0.000 (-4.214)

These results suggest that H3 is not supported. This may be due to the wider spread of samples for proactive recalls (both positive and negative share price changes), while passive recall samples are more concentrated in the negative direction. Thus, it can be posited that only passive recalls will be punished by the stock market. Conversely, for proactive recalls, the financial consequences can be both positive and negative.

4.2.4. Effects of Hazard Level

Table 7 shows the results of the CAAR by hazard level.

Table 7: Statistical results of cumulative average abnormal return by hazard level

	N	Mean	Std. Deviation	Std. Error	p-value (t-value)
Class I	46	-0.0672	0.1536	0.0226	0.005 (-2.965)
Class II	55	-0.0107	0.0260	0.0035	0.004 (-3.053)
Class III	167	-0.0054	0.0220	0.0017	0.002 (-3.173)
N/A	28	-0.0341	0.1208	0.0228	0.147 (-1.494)
Total	296	-0.0187	0.0764	0.0228	0.000 (-4.214)

As is evident from Table 7, the CAAR of the stock will become more negative as the hazard level increases – i.e. from a Class III recall through to a Class I recall. Overall, there is a significant difference according to hazard level ($p= 0.000$).

We conducted a multiple comparison analysis, which determined there is no significant difference ($p= 0.643$) between Class II and Class III recalls; a statistically significant difference is detected between Class I and Class II recalls ($p=0.000$), and between Class I and Class III recalls ($p= 0.000$). Therefore, it can be posited that the stock market reacts differently to hazard level, with more hazardous events leading to greater reductions in share price. The results of the analysis provide support to H4 (A higher level of hazard will lead to a greater reduction in stock price).

5. DISCUSSION AND CONCLUSIONS

In this study we investigate the key characteristics of manufacturer firms' product recalls on the stock market reaction. In Table 8 we present the hypotheses within this study and whether they were supported or unsupported.

Table 8: Summary of tested hypothesis and their empirical support

No.	Hypothesis	Supported?
1	A product recall announcement will generate a negative stock market reaction.	Supported
2	The reduction in stock price related to product recalls will have industry-specific impacts.	Supported
3	A passive product recall strategy will result in more negative abnormal returns than a proactive product recall strategy	Unsupported
4	A higher level of hazard will be associated with more severe market penalty.	Supported

The contributions of this study are twofold. First, the results of the study revealed a significant negative stock market reaction to product recalls, confirming H1. The direction of the stock market reaction on days -1 and 0 is in line with previous literature. However, the magnitude of the reaction (i.e. -1.87%) in our study is significantly higher than in previous studies, where more than one industry was studied, for example -0.81% on day -1 (Jarrell and Peltzman, 1985) and -0.76% on days -1 and 0 (Pruitt and Peterson, 1986) based on US data, and lower when comparing to Zhao et al.'s (2013) findings of -2.21% based on data from China. As this study is based on global data, the result of -1.87% is within this range and possibly reflects the impact of both developed and developing countries.

Second, we provide further granularity in the relationship between product recalls and shareholder's wealth by examining the effects of industry, recall strategy and hazard. Our findings indicated that there were differences in the impact between different sectors. Both, manufacturers in automotive ($t= -4.536$) and pharmaceutical supply chains ($t= -2.774$) had significant negative abnormal returns. This difference is also significant ($p= 0.001$) with pharmaceutical showing more variability when compared to automotive ($SD= 14.174\%$ vs. 2.101%). We suggest there are two distinct reasons behind this. For manufacturers in pharmaceutical supply chains, one third of the total recalls were for the most severe type of recall, i.e. those likely to cause death. They often result not only in the need for a complete drug withdrawal and consequent loss of market, but also in very high litigation costs. For example, Merck's legal costs related to Vioxx withdrawal were estimated to exceed \$7.7bn (Bloomberg News, 2010). For the recalls in automotive supply chains, investors may perceive that the recall is indicative of a more costly and pervasive problem, with the recalled product being shared

between different automotive firms due to supply base over-rationalisation (cf. Choi and Linton, 2011) and sharing of the same supplier (Yan et al., 2015). For example, Takata was a shared supplier of multiple automotive OEM's whose airbag recall impacted more than 20 manufacturers. By comparison, toy recalls were not found to be statistically significant. We suggest this was due to only having four firms in our sample. Whilst it is logical to expect food recalls to have a significant impact, we suggest that due to diversification of brands and range of stock keeping units within food manufacturers' portfolios, the results are to be expected.

Furthermore, rooted in signalling theory, we also examined the effects of recall strategy. The results of the analysis showed no statistically significant difference between the abnormal returns of passive and proactive recalls. Moreover, the effects of proactive recall strategies can have mixed financial impact. This is an important finding and it is in contrast to the extant literature (e.g. and Davidson and Worrell, 1992; Zhao et al., 2013), which suggests significant differences between passive and proactive recalls as well as passive recall strategies being more punitive than proactive. Our finding suggests that manufacturers who adopt proactive recall strategy may not always elicit positive responses from the investors. This suggests that investors may not always see the proactive recall strategy in the same light as consumers, potentially interpreting them as a signal of more severe product hazard, potential financial damage or, as shown in the study of Hora et al. (2011) - longer recall times.

The effects of hazard have been largely left out of examinations of product recall announcements on cross-sectorial samples. We have shown that higher hazards lead to greater negative abnormal returns, and such plays an important role in the directionality and the magnitude of stock price movement for three key reasons; a) severe hazards, such as consumers' death, are indicative of products that require costly rectification or even a complete withdrawal from an entire supply chain; b) the more severe the hazard, the higher the expected litigation costs and; c) extensive media coverage of recalls associated with severe hazard is resulting in greater disutility by stakeholders. Our findings extend the findings of Ni et al. (2014), Ahmed et al. (2002) and Thomsen and McKenzie (2001), showing that irrespective of the structural position of a firm in a supply chain, investors will react more strongly to recalls that are associated with the higher risk of injury or death.

5.1. Managerial implications

Given the global nature of supply chains, supply base rationalization, tougher regulations and economic pressures, product recalls will remain ubiquitous. It is unlikely that a firm could change sector to one that was less sensitive to recall announcements, unlike the pharmaceutical and automotive sectors. Firms do, however, need to be transparent and proactive when recalling products, as this can result in minimization of short-term as well as long-term financial consequences. Consumers and shareholders are interested in whether a firm cares. The results around hazard and sector also suggest that firms need to be incredibly rigorous in ensuring the safety and quality of their products in various stages, from product development, sourcing, manufacturing and distribution. The manufacturers should also be motivated to play an active role, not only in ensuring internal quality standards, but also to proactively manage their supply network partners.

5.2. Future research

This work examined four sectors; future research could examine a broader range to unveil further sectoral differences and seek to examine whether the source of the recall (e.g. focal firm, partner, supply chain) leads to a greater or lesser impact upon share price. Further, considering the impact of severe hazard on shareholder value, research is needed to improve strategies and quality procedures to mitigate the occurrence of hazard.

In our research, we focussed on major recall announcements published by news agencies. While this is important, the vast majority of recalls do not gain such press attention. However, agencies such as the US CPSC and NHTSA provide data on all recalls reported within their area of responsibility. Further research could evaluate the effects of the full range of recall announcements, to establish further granularity of the financial implications on shareholder values.

Finally, the research could be extended to include other potential mediating factors, such as, the effects of branded and non branded products. For example: do firms with strong brand loyalty suffer lower – or perhaps higher – decreases in share price?

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APPENDIX A: OVERVIEW OF THE EVENT STUDY METHOD

In line with Hendricks and Singhal (2003), we used a modified version of the Fama et al. (1969) market model to estimate the daily share price returns:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \quad (1)$$

Where R_{it} is the return of stock i on day t , R_{mt} is the market return on day t (calculated using the local market index of each stock i). α_i is the intercept of the relationship for stock i , β_i is the slope of the relationship for stock i with the market return R_{mt} , and ε_{it} is the error term for stock i on day t which captures the part of R_{it} that cannot be explained by market movements and captures the effect of firm-specific information. For each company, the change in the intercept ($\hat{\alpha}_i$), the change in the slope ($\hat{\beta}_i$) of the relationship, and the variance of the error term ε_{it} were estimated using Ordinary Least Squares (OLS) regression over a 190-day estimation period. The event window spanned three days to include one day prior to the announcement date (-1) and one day following the announcement date (+1). This was done to both effectively measure the market reaction and control for confounding effects (McWilliams and Siegel 1997). The estimation period (day -201, -12) was ended 10 trading days before the event window to avoid any potential bias caused by the data used to estimate the parameters of the market model (Hendricks and Singhal 2003). The abnormal return for stock i on day t is the difference between the actual price of stock i on day t (R_{it}) and the expected return of stock i on day t ($\hat{\alpha}_i + \hat{\beta}_i R_{mt}$). It is defined as:

$$AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt}) = R_{it} - \hat{\alpha}_i - \hat{\beta}_i R_{mt} \quad (2)$$

From Fama et al. (1969), the average abnormal return across N sample observations of the sample of firms at day t is described as:

$$AAR_t = \sum_{i=1}^{N_t} \frac{AR_{it}}{N_t} \quad (3)$$

Where N is the number of sample companies on day t . In this study, $N=296$. The cumulative average abnormal return (CAAR) over the time period (t_1, \dots, t_2) is the sum of AAR_t and is expressed as:

$$CAAR_{t_1, t_2} = \sum_{t=t_1}^{t_2} AAR_{it} \quad (4)$$

In order to determine whether the abnormal return is different to zero at a statistically significant level, we first standardize the abnormal return by dividing the abnormal return (AAR_{it}) by \hat{S}_{ε_i} , its estimated standard deviation:

$$AAR_{it}^S = \frac{AAR_{it}}{S_{\varepsilon_i}} \quad (5)$$

The test statistic (TS) employed to test the statistical significance of the average abnormal return for day t is thus defined as:

$$TS_t = \sum_{i=1}^N \frac{A_{it}^S}{\sqrt{N}} \quad (6)$$

To evaluate the multiple day test statistics, assume that abnormal returns are independent and identically distributed across time (Hendricks and Singhal 2003). Thus, the t -test over multiple days (t_1, \dots, t_2), TS_c , is presented as:

$$TS_c = \sum_{i=1}^N \frac{(\sum_{t=t_1}^{t=t_2} A_{it})}{\sqrt{\sum_{t=t_1}^{t=t_2} S_{it}^2}} \quad (7)$$